3.1.2 Linear motion

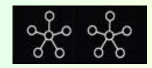
		Learning outcomes	Additional guidance
		Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	(i)	the equations of motion for constant acceleration in a straight line, including motion of bodies falling in a uniform gravitational field without air resistance $v = u + at$ $\quad s = \frac{1}{2}(u+v)t$ $s = ut + \frac{1}{2}at^2$ $\quad v^2 = u^2 + 2as$	*M2.2, M2.4, M3.3* HSW9

(6) M - State the basic assumptions for using the equations of motion
(7) S - Derive the equations of motion
(8) C - Apply the equations of motion to complex situations

Lesson 3. Equations of motion

0:01:00

STARTER: Compare displacement time graphs with velocity time graphs...



HWK (due next lesson): HWK booklet Q1-3 and **glossary**

Kilo 10^3 Sketch 2 graphs to help you visualise your ideas

Mega 10^6

Giga 10^9 What would be each feature on an acceleration time graph?

Key point

	displacement time graphs	velocity time graphs
y-intercept represents..		
Gradient of tangent		
Positive gradient		
Negative gradient		
Zero gradient		
Straight		
Curved		
Area under curve		
when 2 lines coincide...		
Object is stopped when...		
constant acceleration looks like..		

	displacement–time	**velocity–time**
"y" intercept	initial displacement	initial velocity
slope of tangent	instantaneous velocity	instantaneous acceleration
positive slope	motion in positive direction	acceleration in positive direction
negative slope	motion in negative direction	acceleration in negative direction
zero slope	not moving	not accelerating
straight	constant velocity	constant acceleration
curved	changing velocity	changing acceleration
area under curve	–	[change in] displacement
curves coincide	objects have same displacement	objects have same velocity
stopped when…	horizontal	crosses t-axis
uniform acceleration	parabolic	straight

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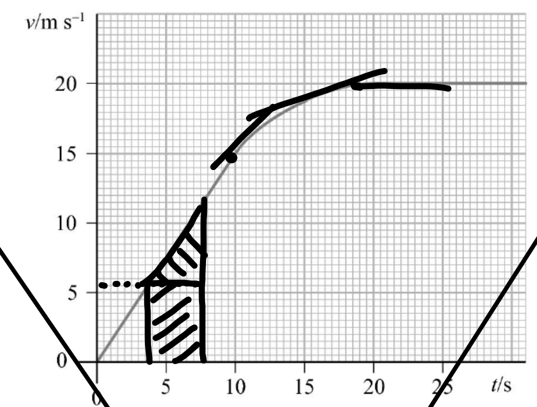
Mini plenary

0:00:00

10 The diagram shows the variation with time t of the velocity v of a car travelling along a straight road.



a Calculate the distance travelled by the car between 4.0 s and 8.0 s. [2]
b Calculate the acceleration of the car at 12.5 s. [3]
c Sketch a graph of acceleration against time for the car. [2]

MS

SA

WWW/EBI

10 a Distance = area under graph from 4 s to 8 s = $\frac{1}{2}(12 + 6.0) \times 4.0$ [1]

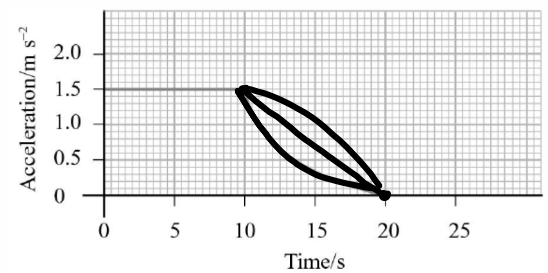
distance = 36 m [1]

b Acceleration = gradient of graph at 12.5 s [1]

acceleration = $\frac{\Delta v}{\Delta t} = \frac{13}{20}$ [1]

acceleration = 0.65 m s^{-2} (allow ± 0.10 m s^{-2}) [1]

c Constant acceleration of 1.5 m s^{-2} from 0 to 10 s [1]
Acceleration gradually decreasing to zero after 10 s [1]



(6) M - State the basic assumptions for using the equations of motion
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5 Equations of motion

0:00:00

Assumptions:

- Constant acceleration
- Considering a single direction only
- No air resistance / friction

Symbol	Quantity
s	displacement (or distance travelled)
u	initial velocity
v	final velocity
a	acceleration
t	time taken for the change in velocity

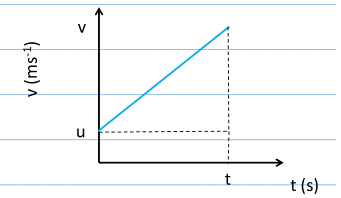
Equation 1

Key point

[redacted]

Where does this come from?

Equation 2



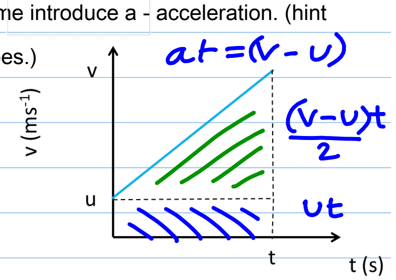
Average velocity [redacted]

displacement = average velocity x time

[redacted]

Equation 3

Calculate displacement (s) from this graph algebraically this time introduce a - acceleration. (hint find the area of both shapes.)



[redacted]

Equation 4

Start with equations 1 and 2 and substitute to remove t:

$v = u + at$ $\qquad$ $s = \frac{(u + v)\,t}{2}$

[redacted]

Extension: Equation 5?

There is one more equatio[redacted]at^2 can you derive it from a V-t graph?

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Lesson 4. Equations of motion. 2

0:00:00

STARTER: Define each variable and state the unit.

$v = u + at \quad s = \frac{(v + u)t}{2}$

HWK (due next lesson): HWK booklet Q3 -4 and glossary + complete summary questions p34 and self mark

Kilo 10^3

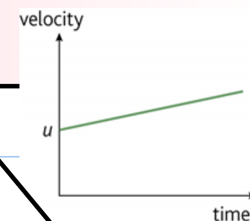
Mega 10^6

Giga 10^9

By substituting equ. 1 into eqn. 2, show that $s = ut + 1/2at^2$

Use the graph to show how $s = ut + 1/2at^2$

Is equal to the area under the graph



(6) M - State the basic assumptions for using the equations of motion
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Example

0:00:00

A mug is dropped from 2.0m.

1. What is its velocity as it hits the ground?

2. How long does it take to fall?

Study tip

The four *s u v a t* equations

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$s = \frac{1}{2}(u + v)t$

$v^2 = u^2 + 2as$

+ve ↓

s = 2.0m
u = 0 ms-1
v = 6.3 ms-1
+ve a = 9.8 ms-2
t =

① $v^2 = \cancel{u^2} + 2as$

$v^2 = 2as$

$v = \sqrt{2as}$

$v = \sqrt{2 \times 9.8 \times 2}$

$v = 6.3\ ms^{-1}$

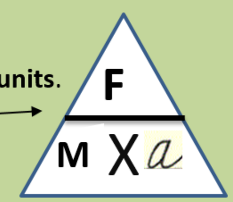
rounding error.

② $v = u + at \quad t = \frac{v - u}{a} = \frac{6.3 - 0}{9.8} = 0.64s$

How to complete calculations:

The 4 part method:

1. Write out all the **data**/quantities you have in the correct **units**.
2. Select the correct **equation** (rearrange?)
3. **Substitute** values into the equation.
4. Write your **answer** with the **unit**.



How to complete SUVAT questions.
- Draw a diagram
- Write SUVAT
- Check feasibility
- consider direction

(6) M - State the basic assumptions for using the equations of motion
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ACTIVITY: Complete the worksheet questions.

Show your full working

Kilo 10^3

Mega 10^6 Start from Q5

Giga 10^9 Lowe: 5.3 and 5.4

Another example

Key point

(6) M - State the basic assumptions for using the equations of motion
(7) S - Derive the equations of motion
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plenary

0:00:00

A ball is thrown in the air with a velocity of 6.00m/s until it stops.

- How high does it go?
- How long does it take to reach that height?

+ve

Kilo 10^3

Mega 10^6

Giga 10^9

What the 5 most important thing when completing a 'suvat' question?

Key point

(6) M - State the basic assumptions for using the equations of motion
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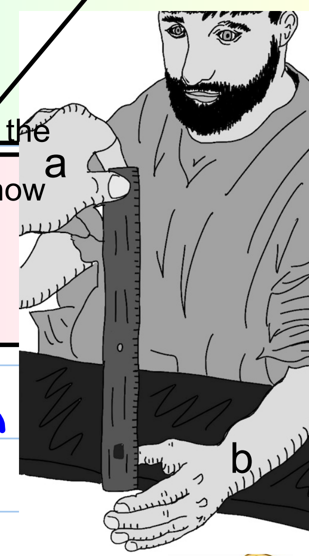
Mini practical

0:00:00

In pairs, person A drops a ruler. person B tries to catch it.

Record the mean distance it travels.

Calculate your mean reaction time. **Ex:** What is the uncertainty in your mean?



Kilo 10^3
Mega 10^6
Giga 10^9

Hint: use the SUVAT approach, and show working

Extension: If your reaction time was halved, what distance would have travelled?

Key point

$s = 22.4\,cm = 0.224\,m$

$u = 0\,ms^{-1}$

$v =$

$a = 9.8\,ms^{-2}$

$t = ?$

$s = \cancel{ut} + \frac{1}{2}at^2$

$s = \frac{1}{2}at^2$

$t = \sqrt{\frac{2s}{a}}$

$t = 0.210\ s$